

# Pluviometric behavior of the city of Porto Velho –RO, Brazil

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**Keywords**— *Accumulated precipitation, climatic anomalies, climatological variables, historical series, statistical hydrology.*

**Abstract**— *Understanding the pluviometric variability of a region is necessary to analyze the existing climatological behaviors. The municipality of Porto Velho has a seasonality with high rainfall rate, which occurs at certain times of the year, but in recent years, the region has undergone climate change, which directly interfere in its hydrological cycle. This event is relate to the natural climate actions coming from the Pacific Ocean, but these events can be accelerated or modified due to anthropic actions that encompass land use and high rate of greenhouse gas emissions. Therefore, the present article aims to analyze and understand rainfall variables from 1961 to 2015, through data obtained from the National Water Agency database of the Hidrometereological station of Porto Velho – RO. When analyzing these data, it was possible to identify that the months with the highest precipitation rate are December, January, February March and April, as well as it was possible to identify that the annual average precipitation rate was 1736 mm, and that the biennium periods had influences of the El Niño and La Niña phenomena regarding their pluviometric volumes. It was also possible to observe that the region of studies present two well-defined seasons, one rainy and one dry, so the present study was able to observe the pluviometric behavior existing in the region during these 54 years.*

## I. INTRODUCTION

The environmental impact caused by the numerous anomalies related to climatological variables has brought numerous disorder to regional extensions. The United Nation's DESA study about the exposure of cities to natural disaster, have found that, although cities located in developing countries have lower risk of exposure to economic losses from natural disaster, these cities have more probability of being in areas worst hit by climatological anomalies (United Nations, 2018).

One of the most important meteorological parameters for the characterization of the climate of a territory is the analysis of pluviometric precipitation (Franca, 2012).

Therefore, the study of the behaviors of the time variables of a locality becomes essential for the planning of socioeconomic activities, such as agriculture, urban planning, transportation, hydrological applications, among others (Santos Neto et al. 2014).

The pluviometric event that occurs in the state of Rondônia occurs due to the meteorological mechanisms present in the Amazon region. Such mechanisms occur due to the high rate of evapotranspiration from the forest and the convergence of humidity present in the Atlantic Ocean (Santos Neto et al. 2014). The extension of the Amazon basin has in its great part a pluviometric volume that varies from 2300 mm / year to 5000 mm / year depending on the region of the basin, this high pluviometric volume comes

from the convective rains, which are frequent in tropical regions. (Franca, 2015)

The city of Porto Velho located in the state of Rondônia has a rainy tropical climate, but has a well-defined dry period where it has a considerable water shortage. Therefore, the region has two seasons, a drought and a rainy season. The high rate of pluviometric precipitation during the rainy season contributes to the dimensioning of water projects, as shown by a study by Bezerra et al. (2010). Although the study region presented a very relevant pluviometric volume between the first and last months of the year, recently it suffered a great influence of drought between the years of 2005 to 2010, which caused numerous problems related to air quality and water supply to the population (Franca, 2012).

According to Silva et. al. (2015), the study of the climatic conditions of a geographic territory is necessary to understand the existing climatic factors, when analyzing such factors can be encountered with anomalies existing in that region, such as high rainfall, frosts, severe droughts, high-speed winds, among others. Therefore, this article presents an analysis of the rainfall variability in the municipality of Porto Velho from 1961 to 2015.

## II. METHODOLOGY

Porto Velho is a Brazilian city capital of the state of Rondônia, located in the western part of the Northern Region of Brazil (08°45'43"S and 63°54'14"O) in the area covered by the Western Amazon in the South-Amazon Plateau. Situated on the east bank of the Madeira River, the city has a territorial area of 34,082 km<sup>2</sup> with 85.2 m in relation to sea level. The climate of the region is super humid tropical, of transition between semi-humid climate of the Midwest region and the predominant equatorial in the North Region. It is characterized with high temperatures, but still provided with enough humidity, with a dry season that lasts about three months, between July and August. The average annual temperature is 25°C and September is the hottest month. For the pluviometric characterization, the data available in the database of accumulated daily precipitations was used by the National Water Agency of the hydrometeorological station of Porto Velho-RO in the periods from 1961 to 2015.

The data available in this database were grouped into daily, monthly, maximum, minimum and average precipitation, and as a complementary analysis, accumulated rainfall, standard error of the mean and standard deviation of total monthly precipitation were calculated.

The calculations and criteria for selecting pluviometric intervals and analyses were adopted according to the methodology described in Costa et al. (2013) and Carneiro et. al. (2013).

## III. RESULTS AND DISCUSSION

By analyzing the accumulated monthly precipitations, one can study how the behavior of rainfall from one month to the next in a given region can quantify how much is varying it. Fig. 1 demonstrates that the rainiest months during the series analyzed were January (513 mm – 1972, 549 mm - 1983, 529 mm – 2006), February (478 mm – 1973, 489 mm – 1983, 467 mm – 2009), March (450 mm – 1970, 438 mm – 1983, 426 mm – 2009), April (417 mm – 1970, 488 mm – 2006), December (471 mm – 1978) where it precipitated up to 400 mm.

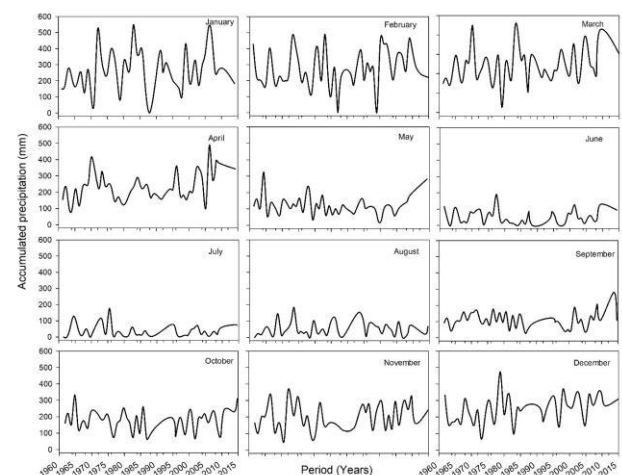


Fig. 1: Accumulated precipitation of the municipality of Porto Velho-RO, between the periods from 1961 to 2015.

The months in which the intermediate precipitations contained between 300 mm and 350 mm occurred were May (325 mm – 1964), October (333 mm – 1964, 309 mm - 2013) and November (327 mm - 1996, 339 mm - 1971, 328 mm - 2009) as shown in Fig. 1, demonstrating a variation from one month to the next. The lowest precipitation occurred in June (191 mm - 1977, 129 mm - 2009), July (178 mm - 1975, 128 mm - 1964), August (184 mm - 1973, 155 mm - 1993) and September (189 mm - 2001, 207 mm - 2008, 280 mm - 2013) these months being precipitating below 300 mm and above 120 mm. It highlights only the month of September where it precipitated 280 mm in the year of 2013.

Since these precipitations are grouped in total accumulated precipitation for each month of every year analyzed, the graphs shown in Fig. 1 are generated, making it possible to verify the behavior of the municipality's

precipitation regime, determining a reduction or increase in accumulated precipitation.

Fig. 2 shows the mean deviation of the maximum precipitations that occurred during the months throughout the historical series studied. It can be observed that the rains of the municipality of Porto Velho are below average, being only the months of December, January, February and March where the highest precipitation is shown, and in the months of January and February the precipitation was above 370 mm, making these the highest indexes above the average. However, these also show the precipitations below average over the years, where in the other months the precipitations are close to the trend line occurring rains closer to the average in June, July and August.

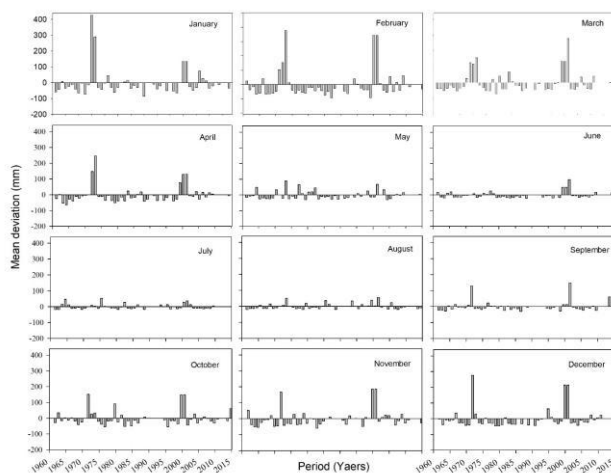


Fig. 2: Mean deviation of rainfall in the municipality of Porto Velho-RO, between the periods of 1961 to 2015.

Fig. 3 shows the total accumulated annually precipitation for 54 years in the municipality of Porto Velho – RO.

We can observe that the years with the highest incidence of rain were 1972 (2256 mm), 1973 (2464 mm), 1974 (2373 mm), 1975 (2238), 1983 (2468 mm), 2001 (2291 mm), 2002 (2286 mm), 2006 (2711 mm), 2007 (2462 mm), 2008 (2281 mm), 2009 (2842 mm), and 2014 (2341 mm). In these years, the precipitation occurred above 2200 mm / year, with an average annual for the years studied ranging from 1860 mm / year to 1601 mm / year.

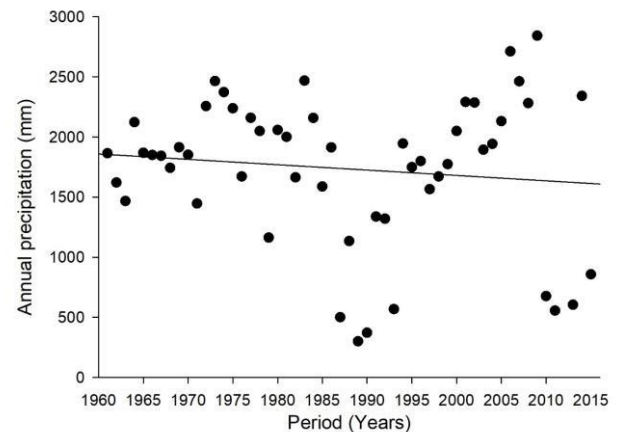


Fig. 3: Graphic dispersion of the annual precipitation of the municipality of Porto Velho-RO, between the periods of 1961 to 2015.

Intermediate occurrences of positive precipitation, with an interval of 1880 mm/year to 2190 mm/year were 1964 (2123 mm), 1969 (1914 mm), 1977 (2159 mm), 1978 (2049 mm), 1980 (2058 mm), 1981 (200 mm), 1984 (2158 mm), 1986 (1913 mm), 1994 (1945 mm), 2000 (2049 mm), 2003 (1894 mm), 2004 (1942 mm), 2005 (2131 mm).

The years that occurred precipitations below the expected average for the year were 1963 (1467 mm), 1971 (1446 mm), 1979 (1162 mm), 1987 (500 mm), 1988 (1133 mm), 1989 (299 mm), 1990 (371 mm), 1991 (1337 mm), 1992 (1320 mm), 1993 (567 mm), 2010 (675 mm), 2011 (555 mm), 2013 (604 mm) and 2015 (856 mm). In these periods, the incidence of rain recorded annually was lower than 1500 mm/year. The other years had a precipitation close to the trend line that varies from 1860 mm/year to 1601 mm/year.

In Fig. 3, we can observe the anomalies existing in the years 1987, 1989, 1990, 1993, 2010, 2011, 2013 and 2015. In these periods, there were incidences of rain less than 1000 mm/year, where we can consider that there was a relevant drought contributing to the decrease in the hydric resources of the region. On the other hand, the years 1973, 1974, 1983, 2006, 2007, 2009 and 2015 presented precipitation above 2300 mm/year, contributing significantly to the cycle of hydro resources of the studied region.

If we look at the biennia, 1975/1976 (567 mm), 1978/1979 (887 mm), 1984/1985 (571 mm), 1986/1987 (1413 mm), 1988/1989 (834 mm), 1992/1993 (753 mm), 2009/2010 (2167 mm) and 2014/2015 (1485 mm), we will notice that in these periods there was a difference in pluviometric incidence between one year and another. We can conclude that in one year there was a high

incidence of rain and then a year with reduction of rainfall, which demonstrates a climatic interference existing in the region. Such interference may have occurred due to the El Niño/La Niña phenomena, originated in the Equatorial Pacific Ocean and provoked by the alterations or anomalies of the sea surface temperature approximate to the west coast of South America. These events occur with a periodicity of four or seven years and, in the periods mentioned above it is demonstrate that the high and low rainfall indices had the influence of such phenomena, according to Mendonça (2009). Paula et. al. (2010) highlights also that the pluviometric rate of the regions when affected by this phenomena it is responsible to soil and water losses from crops, occasioning in the erosive process of the soil.

The average annual pluviometric precipitation of Porto Velho during the study period from 1961 to 2015 was 1736 mm/year. In this period, the months with the highest pluviometric incidence were November (199 mm), December (250 mm), January (270 mm), February (273 mm), March (245 mm) and April (231 mm). The months with the lowest precipitation index were June (51 mm), July (39 mm) and August (51 mm). The months of May and October, that presented an indicator of precipitation around 119 mm and 110 mm, are characterize as the months of transition of season, considering that the city of study has two well-defined seasons, one of rain that runs from November to April and one of drought that goes from June to September. September points to a monthly average of 110 mm.

September it is the month with highest temperatures in the country, and as demonstrated by Silva et. al (2020) in the pluviometric characterization study of another Brazilian municipality, located this time in the regional center of the country, it also represents one of the months with lowest rainfall incidence.

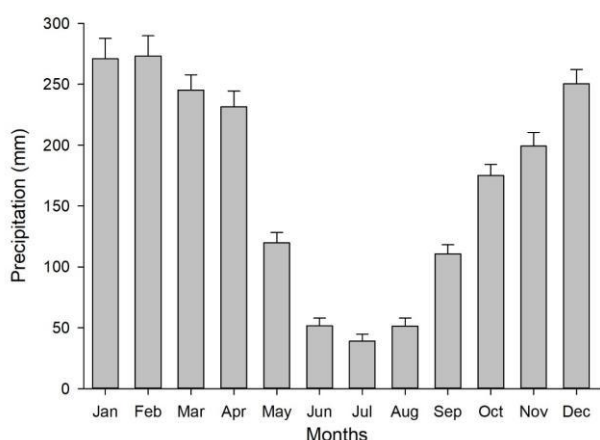


Fig. 4: Climatological Normal of the municipality of Porto Velho - RO.

#### IV. CONCLUSION

The study region is characterize by two well-defined seasons, one rainy that covers the months of November to April and a drought that comprises from June to September.

The months with the highest rainfall are December, January, February with rainfall rates ranging from 250 to 273 mm.

The anomalies studied during the 54 years of analysis in the Porto Velho region showed that the biennial periods had the influence of el niño/la niña phenomena on the incidence of pluviometric precipitations.

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